
ताजा कंक्रीट — नमूने लेना, परीक्षण एवं विश्लेषण पद्धतियाँ

भाग 4 ताजा कंक्रीट की में वायु की मात्रा-सामग्री निर्धारण
(पहला पुनरीक्षण)

Fresh Concrete — Methods of Sampling, Testing and Analysis

Part 4 Determination of Air Content of Fresh Concrete
(*First Revision*)

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भारतीय मानक ब्यूरो

BUREAU OF INDIAN STANDARDS

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FOREWORD

This Indian Standard (Part 4) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

Testing plays an important role in controlling the quality of cement concrete work. Systematic testing of the raw materials, the fresh concrete and the hardened concrete, is an inseparable part of any quality control programme for concrete. This helps to achieve a higher efficiency of the materials used and greater assurance of the performance of the concrete, in regard to workability, strength and durability. The test methods used should be simple, direct and convenient to apply. This standard was formulated with this objective in view.

This standard was first published in 1959. In this revision, it was decided to review and update the various existing test methods of fresh concrete taking into consideration the latest international practices and developments in this field in the country, and also introduced certain new test methods, wherever required. In the process, the various existing test methods covered in IS 1199 : 1959 'Methods of sampling and analysis of concrete', have been revised. The revision of the standard is being brought out taking into consideration primarily the corresponding ISO Standards, while also examining the other best practices world over and in the country. In addition, test methods for determination of properties of new types of concrete like self compacting concrete have been included, covering tests such as consistency, viscosity, passing ability and segregation resistance. Also, for better understanding and implementation, some of the other test methods which were spread over in other Indian Standards have been brought together under the fold of IS 1199 as its various parts, such as the setting time of concrete by penetration method and, water soluble and acid soluble chlorides in mortar and concrete. This is with a view to making the standard complete in all respects, and rendering it a comprehensive source of provisions for testing of concrete and reference in other Indian Standards.

In this revision, IS 1199 has been split in to nine parts. The other parts in the series are:

- Part 1 Sampling of fresh concrete
- Part 2 Determination of consistency of fresh concrete
- Part 3 Determination of density of fresh concrete
- Part 5 Making and curing of test specimens
- Part 6 Tests on fresh self compacting concrete
- Part 7 Determination of setting time of concrete by penetration resistance
- Part 8 Determination of water soluble and acid soluble chlorides in mortar and concrete
- Part 9 Analysis of freshly mixed concrete

This standard (Part 4) covers the procedures for determination of air content of fresh concrete.

These test methods shall be applicable as and when published in place of the corresponding provisions given in IS 1199 : 1959. IS 1199 : 1959 shall be superseded after the publication of all the parts of the standard.

This revision of the standard has been taken up to incorporate the modifications found necessary in the light of experience gained in its use and also to bring it in line with the latest development on the subject. Significant provisions in this revision are highlighted below:

- a) Procedures for determination of air content of fresh concrete have been aligned with the international practices.

(Continued on third cover)

Indian Standard

FRESH CONCRETE — METHODS OF SAMPLING, TESTING AND ANALYSIS

PART 4 DETERMINATION OF AIR CONTENT OF FRESH CONCRETE

(*First Revision*)

1 SCOPE

This standard (Part 4) specifies procedures for determination of air content of fresh concrete. It specifies the following test methods:

- a) Pressure gauge method, and
- b) Water column method.

2 REFERENCES

The standards listed in Annex A contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 4845, IS 6461 (Parts 1 to 12) and the following shall apply.

3.1 Fresh Concrete — Concrete which is fully mixed and still in conditions that is capable of being compacted by chosen method.

4 GENERAL, SAMPLING AND FILLING THE CONTAINER AND COMPACTING THE CONCRETE

Clauses 4.1 to 4.3 and 4.6 to 4.7 are applicable to both the methods described at 4.4 and 4.5, for the determination of air content.

4.1 General

The methods described in this clause are considered adequate for all ordinary types of concrete and mortar, except for concretes or mortar made with highly porous aggregates, where the aggregate correction factor cannot be determined accurately by the technique found satisfactory for the usual types of relatively dense natural aggregates.

4.2 Sampling

Obtain the sample of fresh concrete in accordance with IS 1199 (Part 1).

NOTES

1 When carrying out this test, prevent skin contact with fresh concrete by wearing suitable protective clothing, gloves and footwear. If wet cement or concrete enters the eye, immediately wash it out thoroughly with clean water and seek medical treatment without delay. Wash fresh concrete off the skin immediately.

2 The use of vibrating equipment, such as vibrating tables, can cause damage to joints and loss of sensation due to nerve damage. Moulds, etc, shall be clamped to the table and not held in position using one's hand while they are being vibrated.

4.3 Filling the Container and Compacting the Concrete

4.3.1 Means of Compaction

The means for compacting the concrete in the container shall be one of the following:

- a) *Internal vibrator*, with a minimum frequency of 120 Hz (7 200 cycles per minute). The diameter of the vibrating head shall not exceed one-quarter of the smallest dimension of the container. The vibrator shall meet the requirements of IS 2505.
- b) *Vibrating table*, with a minimum frequency of 50 Hz (3 000 cycles per minute). The vibrating table shall meet the requirements of IS 2514.
- c) *Compacting rod*, of circular cross-section. Straight, made of steel, having a diameter of 16 ± 1 mm, a length of 600 ± 5 mm and shall have rounded ends.
- d) *Compacting bar*, of square or round cross-section with mass greater than 1.8 kg for hand compacting.

4.3.2 Filling the Container

Using the scoop, place the concrete in the container in such a way as to remove as much entrapped air as possible. Place the concrete in three layers, approximately equal in depth. Compact the concrete immediately after placing it in the container, in such a way as to produce full compaction of the concrete, with neither excessive segregation nor laitance. Compact each layer by using one of the methods described in 4.3.3.

The quantity of material used in the final layer shall be

sufficient to fill the container without having to remove excess material. A small quantity of additional concrete may be added, if necessary and further compacted in order to fill the container.

NOTE — Full compaction is achieved using mechanical vibration when there is no further appearance of large air bubbles on the surface of the concrete and the surface becomes relatively smooth with a glazed appearance, without excessive segregation.

4.3.3 Compacting the Concrete

Compact the concrete by one of the methods described below.

4.3.3.1 Mechanical vibration

4.3.3.1.1 Compacting with internal vibrator

Apply the vibration for the minimum duration necessary to achieve full compaction of the concrete. Avoid over vibration, which may cause loss of entrained air. Care should be taken not to damage the container. The use of a filling frame is recommended.

Ensure that the vibrator is kept vertical and not allowed to touch the bottom or sides of the container.

NOTE — Laboratory tests have shown that when using an internal vibrator, great care is needed, if loss of entrained air is to be avoided.

4.3.3.1.2 Compacting with vibrating table

Apply the vibration for the minimum duration necessary to achieve full compaction of the concrete. The container should be attached firmly to the table. Avoid over-vibration, which may cause loss of entrained air.

4.3.3.2 Hand compaction with compacting rod or bar

Distribute the strokes of the compacting rod or bar in a uniform manner over the cross-section of the mould. Ensure that the compacting rod or bar does not forcibly strike the bottom of the container when compacting the first layer, nor penetrate significantly any previous layers. Subject the concrete to at least 25 strokes per layer. In order to remove pockets of entrapped air but not the entrained air, after compaction of each layer, tap the sides of the container smartly with the mallet until large bubbles of air cease to appear on the surface and depressions left by the compacting rod or bar are removed.

4.4 Pressure Gauge Method

4.4.1 Principle

A known volume of air at a known pressure is merged in a sealed air chamber with the unknown volume of air in the concrete sample. The dial on the pressure gauge is calibrated in terms of percentage of air for the resultant pressure.

4.4.2 Apparatus

The apparatus may be calibrated as per procedure in Annex B. At the time of the test, the apparatus shall be in calibration. It is recommended that the apparatus be calibrated at a frequency dependent on the use but at least once per year.

4.4.2.1 Pressure gauge method apparatus shall consists of the following items:

- a) *Container*, a flanged cylindrical vessel, of steel or other hard metal, not readily attacked by cement paste, having minimum capacity of at least 0.005 m³ (5 litre) and ratio of diameter to height of not less than 0.75 and not more than 1.25. The outer rim and the interior surfaces of the vessel shall be machined to a smooth finish. The container shall be watertight. The container and the cover assembly shall be suitable for an operating pressure of approximately 0.2 MPa.

NOTE — The capacity of 0.005 m³ for the container is usually recommended for msa up to 40 mm. For concrete with higher msa, wet sieving of concrete through a 40 mm IS Sieve shall be carried out as per Annex B of IS 1199 (Part 5). Wet-sieving of concrete causes the loss of a small amount of air due to additional handling. The air content of the wet-sieved fraction of concrete is greater than that of the total concrete because the larger size aggregate, which is removed, does not contain air.

- b) *Cover assembly*, consisting of a flanged rigid cover, of steel or any other hard material not readily attacked by cement paste. The outer rim and lower surface of the flange as well as the interior surfaces shall be machined to a smooth finish. The cover shall have provision for being clamped to the container to make a pressure seal without entrapping air at the joint between flanges of the cover and the container.
- c) *Pressure gauge*, fitted to cover assembly, calibrated to indicate air content from 0 to at least 8 percent and preferably 10 percent.

The scale of the gauge shall be graduated as follows:

- 1) Not more than 0.1 percent for the range (0 to 3) percent.
 - 2) Not more than 0.2 percent for the range (3 to 6) percent.
 - 3) Not more than 0.5 percent or the range (6 to 10) percent.
- d) *Air pump*, a pressure pump which may be built into the cover.

4.4.2.2 Scoop, approximately 100 mm wide.

4.4.2.3 Sampling tray, of minimum dimensions 900 mm × 900 mm, 50 mm deep, of rigid construction shall be made from a non-absorbent material not readily attacked by cement paste.

4.4.2.4 Shovel, with a square mouth.

4.4.2.5 Syringe, rubber, suitable for injecting water into the container either through valve *A* or valve *B* (see Fig. 1).

4.4.2.6 Mallet, soft faced with a mass of approximately 250 g.

4.4.3 Procedure

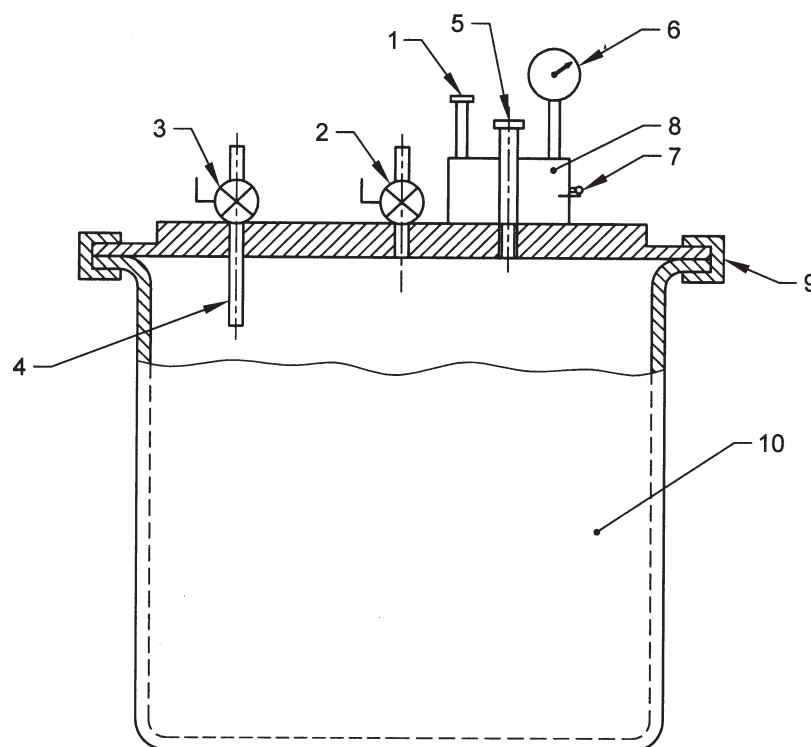
Thoroughly clean the flanges of the container and cover assembly. Clamp the cover assembly in place and ensure that there is a good seal between the cover and the container. Close the main air valve and open valve *A* and valve *B* (see Fig. 1). Using a rubber syringe, inject water through either valve *A* or valve *B* until the water emerges from the other valve. Lightly tap the apparatus with the mallet until all entrapped air is expelled.

Ensure that the air bleeder valve on the air chamber is closed and pump air into the air chamber until the hand on the pressure gauge is on the initial pressure line. After allowing a few seconds for the compressed air to cool to the ambient temperature, stabilize the hand on the pressure gauge at the initial pressure line by further pumping in or bleeding off air as necessary. During this process lightly tap the gauge, close both valve *A* and valve *B* and then open main air valve. Tap the sides of the container sharply. Lightly tap the pressure gauge to stabilize it, then read and record the value indicated in the pressure gauge, which is apparent percentage of air, C_1 . Open valves *A* and *B* in order to release the pressure before the cover assembly is removed.

4.5 Water-Column Method

4.5.1 Principle

Water is introduced to a predetermined height above a sample of compacted concrete of known volume in a sealed container and a predetermined air pressure is applied over the water. The reduction in volume of the air in the concrete sample is measured by observing the



Key

- | | |
|---|---------------------|
| 1 Pump | 6 Pressure gauge |
| 2 Valve B | 7 Air-bleeder valve |
| 3 Valve A | 8 Air-chamber |
| 4 Extension tubing for calibration checks | 9 Clamping device |
| 5 Main air valve | 10 Container |

FIG. 1 APPARATUS FOR DETERMINING AIR CONTENT BY PRESSURE GAUGE METHOD

amount by which the water level is lowered, the water column being calibrated in terms of percentage of air in the concrete sample.

4.5.2 Apparatus

4.5.2.1 General

The apparatus shall be in calibration at the time of the test, using the procedure in Annex C. If the apparatus has been moved to a location that differs in elevation by more than 200 m from the location at which it was last calibrated, it shall be recalibrated (*see* Annex C).

It is recommended that the apparatus be calibrated at a frequency dependent upon use, but at least once per year.

4.5.2.2 Water-column method apparatus, which shall consist of the following items (*see* Fig. 2):

- a) **Container**, a flanged cylindrical vessel, of steel or other hard metal, not readily attacked by cement paste, having a nominal capacity of at least 5 litre and a ratio of diameter to height of not less than 0.75 nor more than 1.25. The outer rim and upper surface of the flange and the interior surfaces of the vessel shall be machined to a smooth finish. The container shall be watertight. The container and the cover assembly shall be suitable for an operating pressure of approximately 0.1 MPa and be sufficiently rigid to limit the pressure

expansion constant, that is, to not more than 0.1 percent air content.

- b) **Cover assembly**, a flanged rigid conical cover, fitted with a stand pipe. The cover shall be of steel or other hard metal not readily attacked by cement paste and shall have interior surfaces inclined at not less than 10° from the surface of the flange. The outer rim and lower surface of the flange and the sloping interior face shall be machined to a smooth finish. The cover shall have provision for being clamped to the container to make a pressure seal without entrapping air at the joint between the flanges of the cover and the container.
- c) **Standpipe**, consisting of a graduated glass tube of uniform bore or a metal tube of uniform bore with a glass gauge attached.

The graduated scale shall indicate air content of 0 to at least 8 percent and preferably 10 percent. The scale shall be graduated with divisions every 0.1 percent air content, the divisions being not less than 2 mm apart.

NOTE — A scale in which 25 mm represents 1 percent of air content is convenient.

- d) **Cover**, the cover shall be fitted with a suitable device for venting of the air chamber, a non-return air-inlet valve and a small valve for bleeding off water.

The applied pressure shall be indicated by a

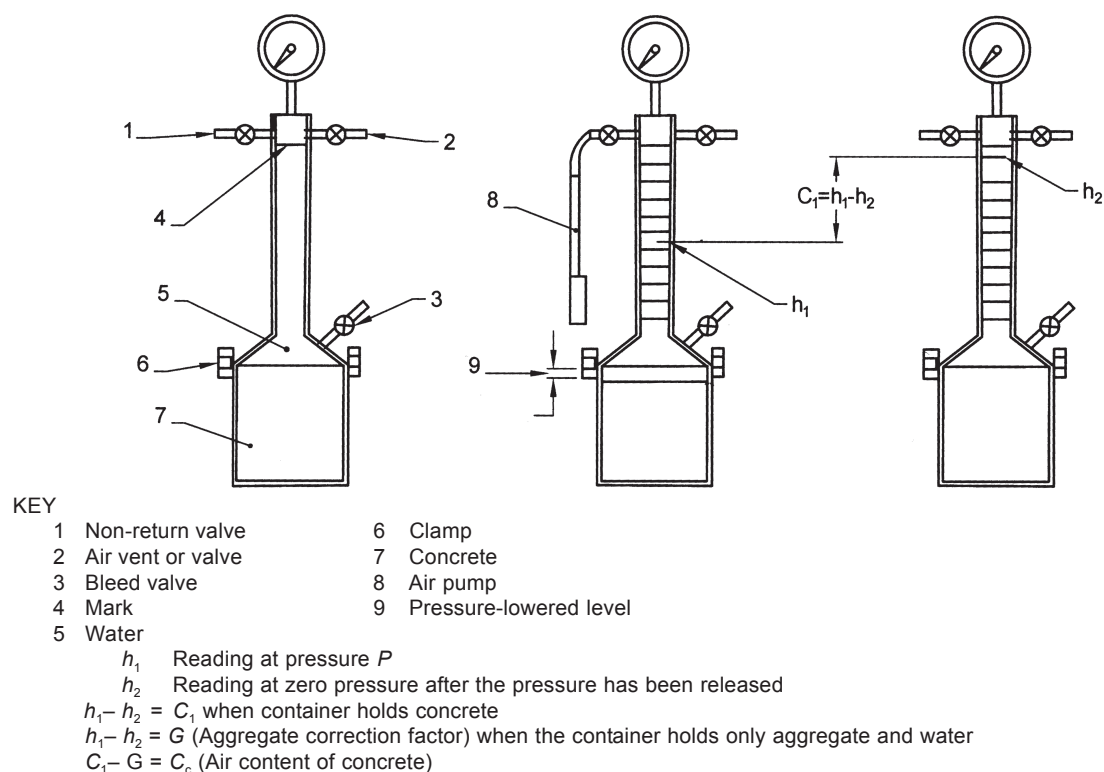


FIG. 2 APPARATUS FOR DETERMINING AIR CONTENT BY WATER-COLUMN METHOD

pressure gauge connected to the air chamber above the water column. The gauge shall be graduated with divisions every 0.005 MPa, the divisions being not less than 2 mm apart. The gauge shall have a full-scale reading of 0.2 MPa.

- e) *Deflecting plate* or *spray tube*, a thin non-corrodible disc of not less than 100 mm diameter to minimize disturbance of the concrete when water is added to the apparatus. Alternatively, a brass spray tube of appropriate diameter that may be an integral part of the cover assembly or provided separately may be used. The spray tube shall be constructed so that when water is added to the container, it is sprayed onto the walls of the cover in such a manner as to flow down the sides causing minimum disturbance to the concrete.
- f) *Air (pressure) pump*, with a lead facilitating connection to the non-return air-inlet valve on the cover assembly.

4.5.2.3 *Scoop*, approximately 100 mm wide.

4.5.2.4 *Remixing tray*, of rigid construction, made from a non-absorbent material not readily attacked by cement paste.

It shall be of appropriate dimensions such that the concrete can be thoroughly remixed using a square-mouthed shovel.

4.5.2.5 *Shovel*, with a square blade.

4.5.2.6 *Container*, fitted with a spout, having a capacity of 2 litre to 5 litre, to fill the apparatus with water.

4.5.2.7 *Mallet*, soft-faced, with a mass of approximately 250 g.

4.5.3 *Filling the Container and Compacting the Concrete*

Fill the container and compact the concrete as described in 4.3.

4.5.4 *Procedure*

Thoroughly clean the flanges of the container and cover assembly. In the absence of the spray tube, place the deflecting plate, centrally on the concrete and press it into contact. Clamp the cover assembly in place, and ensure that there is good pressure seal between the cover and the container. Fill the apparatus with water and tap lightly with the mallet to remove air adhering to the interior surfaces of the cover. Bring the level of water in the standpipe to zero by bleeding through the small valve with the air vent open. Close the air vent and apply the operating pressure, P , by means of the air pump. Record the reading on the gauge tube, h_1 , and release the pressure. Read the gauge tube again and if the reading h_2 is 0.2 percent air content or less, record

the value $(h_1 - h_2)$ as the apparent air content, C_1 , to the nearest 0.1 percent air by volume. If h_2 is greater than 0.2 percent air content, apply the operating pressure, P , again, giving a gauge tube reading h_3 and a final reading h_4 after release of the pressure. If $(h_4 - h_2)$ is 0.1 percent air content or less, record the value $(h_3 - h_4)$ as the apparent air content. If $(h_4 - h_2)$ is greater than 0.1 percent air content, it is possible that leakage is occurring and the test shall be disregarded.

4.6 Calculation and Expression of Results

4.6.1 Air Content of the Sample Tested

Calculate the air content, C_c , of the concrete in the container from following equation:

$$C_c = C_1 - G$$

where

C_1 = apparent air content, expressed to the nearest 0.1 percent of the sample tested, and

G = aggregate correction factor, expressed to the nearest 0.1 percent.

The aggregate correction factor shall be determined as described in Annex D (for pressure gauge method) and Annex E (for water column method). Express the air content as a percentage to the nearest 0.1 percent.

4.7 Test Report

The test report shall include the following:

- a) Identification of the test sample;
- b) Location of performance of test;
- c) Time and date of performance of test;
- d) Temperature of the remixed sample (optional);
- e) Observations on condition of test sample (optional);
- f) Consistence of the concrete;
- g) Method of compaction:
 - 1) for mechanical compaction, the duration,
 - 2) for hand compaction, the number of strokes;
- h) Identification of person carrying out the test or part of the test;
- j) Any deviation from standard test method;
- k) Declaration by the person carrying out the test that it was carried out in accordance with this standard, except as noted in (j).
- m) Aggregate correction factor (where appropriate);
- n) Identification of test method and procedure used, that is, pressure-gauge method or water-column method;
- p) Information relevant to the specific test, like altitude;
- q) Measured apparent air content; and
- r) Calculated air content (C_c) of the concrete.

ANNEX A

(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
1199	Fresh concrete — Methods of sampling, testing and analysis:	(Part 1) : 1972	Concrete aggregates
(Part 1) : 2018	Sampling of fresh concrete (<i>first revision</i>)	(Part 2) : 1972	Materials (Other than cement and aggregate)
(Part 5) : 2018	Making and curing of test specimens (<i>first revision</i>)	(Part 3) : 1972	Concrete reinforcement
(Part 6) : 2018	Tests on fresh self compacting concrete (<i>first revision</i>)	(Part 4) : 1972	Types of concrete
2505 : 1992	Concrete vibrators — Immersion type — General requirements (<i>third revision</i>)	(Part 5) : 1972	Formwork for concrete
2514 : 1963	Specification for concrete vibrating tables	(Part 6) : 1972	Equipment, tools and plant
4845 : 1968	Definitions and terminology relating to hydraulic cement	(Part 7) : 1973	Mixing, laying, compaction, curing and other construction aspects
6461	Glossary of terms relating to cement concrete:	(Part 8) : 1973	Properties of concrete
		(Part 9) : 1973	Structural aspects
		(Part 10) : 1973	Tests and testing apparatus
		(Part 11) : 1973	Prestressed concrete
		(Part 12) : 1973	Miscellaneous

ANNEX B

(Clause 4.4.2)

CALIBRATION OF APPARATUS FOR PRESSURE GAUGE METHOD

B-1 The calibration test detailed shall be made as frequently as necessary to check the accuracy of the graduations indicating air content on the dial of the pressure gauge. Recalibration of the apparatus is not required with changes in elevation at which it is used or with changes in atmospheric pressure.

B-2 APPARATUS

The apparatus for calibration shall be as follows:

- a) *Calibration cylinder* — It shall be made of brass or other non-corrodible metal, which may be integral with the cover assembly. The calibration cylinder shall consist of cylindrical measure having an internal volume equal to approximately 3 to 6 percent of the volume of the measuring bowl.

- b) *Transparent plate* — It shall be rigid and transparent with a minimum thickness of 5 mm, suitable for use as a closure for the container.
- c) *Balances* — These shall be capable of weighing up to 1 kg to an accuracy of ± 0.5 g, over the range used in the test and up to 20 kg to an accuracy of ± 5 g over the range used in the test.

B-3 CHECKING THE CAPACITY OF THE CONTAINER

The capacity of the container is found by determining the mass of water, $m_{w,con}$, required to fill it. Smear a thin film of grease on the flange of the container to make a watertight joint between the transparent plate and the top of the container. Fill the container with water

at ambient temperature and place the transparent plate over it to eliminate any convex meniscus. Wipe away surplus water and determine the mass of the container filled with water by weighing on the balance.

B-4 CHECKING AIR CONTENT GRADUATIONS ON THE PRESSURE GAUGE

Screw the extension tubing (*see* Fig. 1) into the threaded hole beneath valve *A* on the underside of the cover assembly and clamp the cover assembly into place, taking care to ensure that there is a good pressure seal between cover and container. Close main air valve and open valves *A* and *B*. Add water through valve *A* until all trapped air has been expelled through valve *B*. Pump air into the air chamber until the pressure reaches the indicated initial pressure line. After allowing a few seconds for the compressed air to cool to ambient temperature, stabilize the indicator on the pressure gauge at the initial pressure line by further pumping in or bleeding off air as necessary. During this process lightly tap the gauge and close valve *B*.

Remove the water from the apparatus to the calibration cylinder in just sufficient quantity to fill it completely or up to a predetermined line marked on it, then determine the mass, $m_{w,dis}$, of water displaced by weighing on the balance.

Depending upon the particular apparatus design, control the flow of water either by opening valve *A* and using the main air valve to control the flow, or by opening the main air valve and using valve *A* to control the flow. Then release the pressure in the container by opening valve *B* (If the apparatus employs an auxiliary tube for filling the calibration cylinder, open valve *A* so that the tube is drained back into the container, or alternatively, if the calibration is an integral part of the cover assembly, close valve *A* immediately after filling the calibration vessel and leave it closed until the test has been completed.). The volume of air in the container is now equal to the volume of the displaced water; close all valves, pump air into the air chamber until the pressure reaches the initial pressure line, and then open the main air valve. The air content indicated by the pressure gauge corresponds to the percentage of air, C_1 , determined to be in the container, where,

$$C_1 = m_{w,dis} / m_{w,con} \times 100 \text{ percent}$$

If two or more determinations show the same variation from the correct air content, reset the hand on the pressure gauge to the correct air content and repeat the test until the gauge reading corresponds to the calibrated air content within 0.1 percent air content.

ANNEX C

(Clause 4.5.2.1)

CALIBRATION OF APPARATUS — WATER-COLUMN METHOD

C-1 GENERAL

The calibration tests described in C-3, C-4, C-5 and C-6 shall be made at the time of the initial calibration of the apparatus and at any time when it is necessary to check whether the capacity of the calibration cylinder or container may have changed. The calibration test described in C-7 and C-8 shall be made as frequently as necessary to check the pressure gauge in order to ensure that the proper gauge pressure, P , is being used. Recalibration of the apparatus shall also be required when the location at which it is to be used varies in elevation by more than 200 m from that at which it was last calibrated.

C-2 APPARATUS

The apparatus shall be as follows:

- a) *Calibration cylinder*, hollow, made of brass or other strong non-corroding metal, having a capacity of approximately 0.3 litre. The rim of the cylinder shall be machined to a smooth plane surface at right angles to the axis of the cylinder.
- b) *Support*, for the calibration cylinder, made of non-corroding material and which allows free flow of water into and out of the cylinder in the inverted position.
- c) *Spring*, non-corroding coil, spring or equivalent for retaining the calibration cylinder in place.
- d) *Transparent plates*, two rigid plates with a minimum thickness of 5 mm, one suitable for

use as a closure for the calibration cylinder and one as a closure for the container.

- e) *Balances*, capable of weighing up to 1 kg to an accuracy of ± 0.5 g, over the range used in the test and up to 20 kg to an accuracy of ± 5 g over the range used in the test.

C-3 CAPACITY OF THE CALIBRATION CYLINDER

Using the 1 kg balance, determine the capacity of the calibration cylinder by measuring the mass of water required to fill it. For this purpose, fill the weighed cylinder with water at temperature of $27 \pm 2^\circ\text{C}$ and carefully cover it with the previously weighed transparent plate, ensuring that no air bubbles are trapped under the plate and that surplus water is wiped away before weighing the assembly. By repeating this procedure, make a total of three weighings of the covered cylinder filled with water. Calculate the average mass, $m_{w,cyl}$, of water contained in the full cylinder and record it to the nearest 0.5 g.

C-4 CAPACITY OF THE CONTAINER

Using the 20 kg balance, determine the capacity of the container by measuring the mass of water required to fill it. For this purpose, smear a thin film of grease on the flange of the container, and, after weighing together with the transparent plate, fill with water at temperature of $27 \pm 2^\circ\text{C}$, and make a watertight joint by sliding the transparent plate over the top of the container, ensuring that no air bubbles are trapped under the plate and that surplus water is wiped away before weighing the assembly. By repeating this procedure, make a total of three weighings of the covered container filled with water. Calculate the average mass, $m_{w,con}$, of water contained in the full container and record it to the nearest 5 g.

C-5 PRESSURE EXPANSION CONSTANT

The pressure expansion constant, e , is determined by filling the apparatus with water, making sure that all entrapped air has been removed and that the water level is exactly on the zero mark, and applying an air pressure of 100 kPa. The reading of water column (in percent air content) will be the pressure expansion constant, e , for the apparatus.

Strictly speaking, the air pressure applied during this procedure should be the required operating pressure, P , determined as in C-7. However, as the value of e is needed to determine P by way of the calibration constant K , a logically closed cycle of operations exists. In practice, the change in e due to a change in P is small enough to be ignored. As P is commonly about 100 kPa, this value is prescribed to overcome the problem. Its use will lead to a value of e that is sufficiently accurate for the test.

C-6 CALIBRATION CONSTANT

The calibration constant, K , is the reading needed on the air content scale during the routine calibration procedure to obtain the gauge pressure required to make the graduations on the air content scale correspond directly to the percentage of air introduced into the container by the calibration cylinder when the container is full of water.

The constant, K , is generally calculated in accordance with equation given below:

$$K = 0.98 \times R + e$$

where

- e = pressure expansion constant (*see* C-5); and
- R = capacity of the calibration cylinder expressed relative to the capacity of the container and is calculated as follows (*see* C-3 and C-4):

$$R = \frac{m_{w,cyl}}{m_{w,con}} \times 100$$

NOTE — The factor 0.98 is used to correct for the reduction in the volume of air in the calibration vessel when it is compressed by a depth of water equal to the depth of the container. This factor is approximately 0.98 for a 200 mm deep container at sea level. Its value decreases to approximately 0.975 at 1 500 m above sea level and 0.970 at 4 000 m above sea level. The value of the constant will decrease by about 0.01 for each 100 mm increase in bowl depth. Hence the term $0.98 \times R$ represents the effective volume of the calibration vessel, expressed as a percentage of the container under normal operating conditions.

C-7 REQUIRED OPERATING PRESSURE

Place the calibration cylinder support centrally on the bottom of the clean container and place the cylinder on the support with its open end downward. Place the coil spring on the cylinder and clamp the cover assembly carefully in place.

Fill the apparatus with water at ambient temperature to a level above the zero mark on the air content scale. Close the air vent and pump air into the apparatus approximately to the operating pressure (about 100 kPa). Lightly tap the sides and cover with the mallet to remove as much entrapped air as possible adhering to the interior surfaces of the apparatus and gradually reduce the pressure by opening the vent. Bring the water level exactly to the zero mark by bleeding water through the small valve in the conical cover and close the air vent. Apply pressure by means of the pump until the reading of the water level equals the calibration constant, K (*see* C-6). Record the pressure, P , indicated on the pressure gauge. Gradually release the pressure by opening the vent until zero pressure is indicated. If the water level returns to a reading less than 0.05 percent air content, take the pressure, P , as the operating

pressure. If the water level fails to return to a reading below 0.05 percent air content, check the apparatus for leakage and repeat the procedure.

C-8 ALTERNATIVE OPERATING PRESSURE

The range of air contents that can be measured with a particular apparatus can be extended by determining an appropriate alternative operating pressure. For example, if the range is to be doubled, the alternative

operating pressure, P_1 , is that for which the apparatus indicates half of the calibration reading, K (see C-6).

Exact calibration requires the determination of the pressure expansion constant, e (see C-5), for the reduced operating pressure but, since the change in the pressure expansion constant can normally be disregarded, the alternative operating pressure can be determined during the determination of the normal operating pressure (see C-7).

ANNEX D

(Clause 4.6.1)

AGGREGATE CORRECTION FACTOR FOR PRESSURE GAUGE METHOD

D-1 GENERAL

The aggregate correction factor will vary with different aggregates and although ordinarily it will remain reasonably constant for a particular aggregate, an occasional check shall be carried out. The aggregate correction factor can be determined only by a test, as it is not directly related to the water absorption of the particles.

D-2 AGGREGATE SAMPLE SIZE

Determine the aggregate correction factor by applying the operating pressure on a combined sample of the coarse and fine aggregates in the approximate amounts, proportions and moisture conditions that exist in the concrete sample. Obtain the sample of aggregate either by washing the cement through a 150 μm sieve from the concrete sample tested or by using a combined sample of fine and coarse aggregate similar to that used in the concrete. In the latter case calculate the masses, m_f and m_c , of fine and coarse aggregate, respectively, to be used from equations given below:

$$m_f = V_o \rho_{fr} f_f$$

$$m_c = V_o \rho_{fr} f_c$$

where

f_f and f_c = proportions, of the fine and the coarse aggregate, respectively in fractions by mass of the total concrete mix (aggregates, cement and water);

V_o = capacity, of the container determined as specified in B-3, in m^3 , and

ρ_{fr} = density of concrete to be tested, determined in accordance with IS 1199 (Part 3) or calculated from the known

proportions and densities of the materials and the nominal air content, in kg/m^3 .

D-3 FILLING THE CONTAINER

Partially fill the container of the apparatus with water, then introduce the combined sample of aggregate in small scoops. This shall be done in such a manner as to entrap as little air as possible. If necessary, add additional water to inundate all of the aggregate. After the addition of each scoopful, remove any foam promptly, then stir the aggregate with the compacting bar and tap the container with the mallet to release any entrapped air.

D-4 DETERMINATION OF AGGREGATE CORRECTION FACTOR

When all the aggregate has been placed in the container and inundated for at least 5 min, wipe clean the flanges of the container and the cover assembly thoroughly and clamp the cover assembly into position, so that a pressure tight seal is obtained. Close the main valve and open valves *A* and *C*. Using the rubber syringe, inject water through either valve *A* or valve *B* until water emerges from the other valve. Tap the apparatus lightly with the mallet until all entrapped air is expelled from this same valve. Remove a volume of water from the container approximately equivalent to the volume of air that would be contained in a typical concrete sample of a size equal to the volume of the container. Remove the water in the apparatus in the manner described in B-4 for the calibration test. Complete the test using the procedure described in 4.4.3. The aggregate correction factor, G , expressed as a percentage of the capacity of the container, is equal to the reading on the air content scale minus the volume of water removed from the container.

ANNEX E

(Clause 4.6.1)

AGGREGATE CORRECTION FACTOR FOR WATER COLUMN METHOD

E-1 GENERAL

The aggregate correction factor will vary with different aggregates and, although it will remain reasonably constant for a particular aggregate, an occasional check shall be carried out. The aggregate correction factor can be determined only by a test, as it is not directly related to the water absorption of the particles.

E-2 AGGREGATE SAMPLE SIZE

Determine the aggregate correction factor by applying the operating pressure on a combined sample of the coarse and fine aggregates in the approximate amounts, proportions and moisture conditions that exist in the concrete sample. Obtain the sample of aggregate either by washing the cement through a 150 µm sieve from the concrete sample tested or by using a combined sample of fine and coarse aggregate similar to that used in the concrete. In the latter case calculate the masses, m_f and m_c , of fine and coarse aggregate, respectively, to be used from equations given below:

$$m_f = V_o \rho_{fr} f_f$$

$$m_c = V_o \rho_{fr} f_c$$

where

f_f and f_c = proportions, of the fine and the coarse aggregate, respectively in fractions by mass of the total concrete mix (aggregates, cement and water);

V_o = capacity, of the container determined as specified in **B-3**, in m^3 , and

ρ_{fr} = density of concrete to be tested, determined in accordance with IS 1199 (Part 3) or calculated from the known

proportions and densities of the materials and the nominal air content, in kg/m^3 .

E-3 FILLING THE CONTAINER

Partially fill the container of the apparatus with water, then introduce the combined sample of aggregate in small scoopfuls. This shall be done in such a manner as to entrap as little air as possible. If necessary, add additional water to inundate all of the aggregate. After the addition of each scoopful, remove any foam promptly, then stir the aggregate with the compacting bar and tap the container with the mallet to release any entrapped air.

E-4 DETERMINATION OF AGGREGATE CORRECTION FACTOR

When all the aggregate has been placed in the container and inundated for at least 5 min, wipe clean the flanges on the container and clamp the cover in position. Fill the apparatus with water and tap lightly with the mallet to remove air adhering to the interior surfaces of the apparatus. Bring the level of the water in the standpipe to zero but bleeding through the small valve with the air vent open. Close the air vent and apply the operating pressure, P , by means of the air pump.

Record the reading of the gauge tube as h_1 , release the pressure and take a further reading, h_2 . Repeat the entire procedure once, obtaining a second pair of readings, h_3 and h_4 . Take the average value of $(h_1 - h_2)$ and $(h_3 - h_4)$ as the aggregate correction factor, G , unless the two value of $(h_1 - h_2)$ and $(h_3 - h_4)$ differ by more than 0.1 percent air content, in which case carry out further determinations until consistent results are obtained.

ANNEX F*(Foreword)***COMMITTEE COMPOSITION****Cement and Concrete Sectional Committee, CED 02**

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(Continued from second cover)

- b) Two test methods for air content determination are covered, namely, pressure gauge method and water column method. The water column has the same principle as the pressure method in IS 1199 : 1959.
- c) Details on filling the containers and compacting the concrete have been elaborated.
- d) Calibration of apparatus and aggregate correction factors have been given in annexure for both the test methods.

In the formulation of this standard, assistance was also derived from ISO 1920-2 : 2016 'Testing of concrete — Part 2: Properties of fresh concrete'.

The composition of the Committee responsible for the formulation of this standard is given in Annex F

In reporting the result of a test or analysis made in accordance with this standard, if the final value observed or calculated is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

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